10-1977

Which Mode Can Save Most Energy? No Simple Answer Exists

Vukan R. Vuchic
University of Pennsylvania, vuchic@seas.upenn.edu

Which Mode Can Save Most Energy? No Simple Answer Exists

Abstract
Written testimony commenting on the CBO's report, "Energy Saving Potential of Urban Mass Transit," submitted for the Senate Committee on Environment and Public Works hearing on the 5th of October,1977.

Disciplines
Engineering | Systems Engineering | Transportation Engineering

Which Mode Can Save Most Energy?

No Simple Answer Exists

Comments on the CBO's report

"Energy Saving Potential of Urban

Mass Transit"

Philadelphia, Pa.
30 September 1977

Vukan R. Vuchic, Ph.D.
Professor of Transportation
Engineering
University of Pennsylvania

Written testimony submitted for the
Senate Committee on Environment and Public
Works hearing on the 5th of October. 1977.

The report "Energy Saving Potential of Urban Mass Transit" represents an unprecedented collection of confused concepts, self-contradictions, elementary errors in data and analyses, and unfounded misleading "recommendations" for federal policies in urban transportation.

It is quite disturbing that a document of such low quality, which has already led to deception of the public through erroneous statements in the press, has been produced by the Congressional Budget Office (CBO), an office supposed to advise the U. S. Congress. Documents with these types of biases and misinformation have in the past been produced by various interest groups and individual extremists; but one would expect far more responsible and higher quality information from a body such as the CBO.

The CBO report abounds with deficiencies in its analysis, data, conclusions, etc.; these are documented in a concise manner later in this testimony. However, the foregoing sharp criticism is based on more than that. The fundamental deficiency of the CBO report is that it discusses the wrong question and produces misleading answers to it. The easiest way to explain the confusion is to present an exact parallel to the issue analyzed in this report from another area.

Suppose that the question is asked which type of air transportation has the best "energy saving potential," and that the study of this problem is undertaken as follows. Energy consumption of Boeing 747, DC-8, Cessna and a Sikorsky helicopter are computed on a per passenger mile basis, but speed, comfort, safety, etc. are not considered. Then "average" conditions of travel by air are found by assuming or manipulating statistics from various companies, routes, airports, etc. Wide variations among these are mentioned, but the analyses are made with single "average" figures only. Finally, the conclusions are made that there has been a widespread misconception about

energy efficiencies of Boeing 747 and DC-8; they have been found to use on the average 11.7% more energy per passenger mile than Cessna and Sikorsky.

It is obvious that this "study" would be considered totally incorrect and absurd. Yet, this is an exact parallel of what the CBO report presents about urban transportation: utilizing such a methodology, the report attempts to find a simplistic answer that one mode is "better" than another mode.

Similar simplistic answers about modes have been "found" in the past by various laymen, lobbyists and extremists. The only professionally correct answer about energy efficiency of modes is that it is not possible to make flat statements that "rail uses more energy than buses" (or vice versa). Since conditions among cities, types of trips, etc. vary greatly, each mode is the most efficient one for certain types of applications. While the fact is that for many trips in suburbs auto is much more efficient than rail transit, it is also true that in corridors with substantial passenger volumes, which exist in many of our cities, no other mode can match energy efficiency of rail transit. Averaging these two, and many other conditions, obviously makes no sense at all.

Documentation of more detailed errors of the CBO report follows here.

A. Purpose and Scope of the CBO Paper

A-1. Energy efficiency is one of the many factors which influence the choice of modes in urban transportation. Although very important, energy cannot be considered as the only element determining which mode is "better" than others. Performance (speed, reliability, etc.), attraction of ridership, costs, impact on urban form, lifestyle and economic vitality, are some of the elements which cannot be ignored.

The CBO report analyzes energy only, but draws on that basis not only sweeping statements about modes, but even evaluates and suggests modifications in legislation for urban transportation. No basis for such statements is given in the report.

A-2. Energy consumption is closely tied to the relationship between transportation systems and urban form. Some modes, primarily rail transit and, under some conditions, exclusive busways, have a much stronger influence on land use patterns than others. Carpools, vanpools and buses on streets have no such influence. The former can therefore be used to induce the urban forms which are more energy efficient and desirable for other reasons.

The CBO overlooks this major factor. On the basis of trends prior to 1973 (when the energy picture changed), the ~~paper~~ report dismisses the possibility or desirability of any changes in the future.

A-3. The proposal of 2.5¢ gasoline tax for transit improvements is criticized in the ~~paper~~ report through a hypothetical use of this tax for "fewer than six Washington Metro systems," an absurd option which nobody has ever proposed. The example is used to "illustrate" how unsound investments in rail transit are! The criticism of the tax proposal is completely out of scope and without basis in the CBO report.

B. Method of Analysis

B-1. The ~~paper~~ report contains many useful statements which define correct procedures for analysis, point out frequent errors, and recognize the extremely broad ranges of modal characteristics and conditions in urban areas. However, the method used for analyses is in direct contradiction to these statements. Two major contradictions are as follows.

B-2. The ~~paper~~ report states that: "For purposes of energy policy, statistical abstractions can be enormously misleading since differences in vehicle characteristics can make the energy intensiveness of any particular vehicle operating pattern differ sharply from the modal average." The ~~paper~~ report then proceeds to deal with and make categorical judgements on statistical averages of not only vehicles, but entire transportation modes! This method, predictably, leads to

the sweeping conclusions about rankings of modes or even single measures of efficiencies of entire modes. This methodology is professionally indefensable and cannot produce valid results.

B-3. The ~~paper~~ report argues that the correct unit for analysis of vehicle energy intensiveness is person-miles, not seat-miles. Then it presents most of the analyses (e.g. Tables 5 and 6) on a confusing vehicle-mile basis, only later returning to passenger miles.

C. Definitions of Modes

C-1. Many concepts used in the report for computations of energy consumption are either confused or incorrect. The most glaring example of these errors and their major influence on the findings is found with respect to the definitions of modes.

Urban transportation modes are defined by three characteristics: type of right-of-way, vehicle technology and type of operation. The CBO treats technologies as if they were modes. Examples of specific errors in definitions are:

-"Vanpools" appear to include interurban travel: round trips of 40-100 miles are quoted. That is a range not normally encompassed by urban transit modes.

-"Bus" is not a single mode: local buses differ drastically in performance, service and energy consumption from express buses.

-"New heavy rail" and "Old heavy rail" are arbitrary and unclear designations. Where do the Dan Ryan Line in Chicago or Quincy Line in Boston belong?

-While none of the rail modes is precisely defined in the "Glossary," the definition of Light Rail is particularly misleading ("Trolleys are the best example"!).

It is obvious that an analysis performed on modes which are in-

correctly defined cannot result in correct conclusions.

C-2. "Basic Energy Components" in Table 1 do not include one of the basic factors: vehicle or mode performance. The entire CBO report ignores this aspect: speed, reliability, passenger attraction, etc., play a major role in the evaluation and utilization of modes. Actually, any analysis disregarding these factors should find that bicycles and motorcycles are superior to all other modes! The only reason the CBO report has not reached this conclusion is becasue it did not consider these modes.

C-3. In many cases modes compared in the report are not serving the same travel demand: carpools and vanpools serve for commuting only; regular transit (bus, trolleybus, rail) serve for total mobility of population - all trip purposes at all times of day. These two groups of modes therefore cannot be compared directly, as if they were fully competitive with each other.

D. Errors and Biases in Energy Computations

D-1. The complexity of energy efficiency in urban transportation requires that numerous assumptions be made. However, correct analysis can be made only if two conditions on such assumptions are met:

-First, the limitations each assumption introduces must not be forgotten. If an average value is used, it must be borne in mind that variations around it exist and that these variations may cause large deviations from the findings based on the assumed single number;

-Second, assumptions must be based on the best professional judgement and not biased toward one system.

The CBO report does not meet either one of these requirements: it makes many assumptions and ignores their limitations; its biases are,

as a rule, in favor of auto/carpool as opposed to transit. However, particularly strong is the bias against rail transit, which is found consistently throughout the report. The supporting facts follow.

D-2. The report emphasizes many times that transit vehicles run many empty miles and includes them into computations. But it ignores the following facts:

-Millions of auto trips are made every day for the purpose of dropping off or picking up a passenger (parents driving teenagers or children; dropping a friend off, etc.). These trips cannot be counted as if they had an average occupancy of 1.5 (2 persons one direction, 1 in the other), but only 0.5, since the driver has no purpose in that trip: he is a chauffer. Such travel corresponds to the empty miles of buses and rail cars. For correct comparison of modes, average car occupancy must incorporate this factor. The CBO report ignores it; the quoted average auto occupancies could be lowered by at least 10-15% due to this omission alone. Energy efficiency is thus correspondingly lower.

-The average occupancies assumed for vanpools are also appreciably lower if the collection-distribution of passengers in suburbs is taken into account in the same manner.

D-3. The comparisons are made as if only rail systems had stations, terminals and yards. While energy consumption for all of these is computed, corresponding items for other modes are ignored. The glaring paradox is when construction, maintenance and lighting for park-and-ride lots are assigned to rail modes, but no such consumption is accounted for in analyzing the auto mode! Specifically, the components of auto-highway system ignored in the study include:

-Energy consumed in the construction and maintenance of private

98-885 O - 77 - 8

garages at homes, stores, offices and other locations; commercial parking lots and structures, etc. The number of parking spaces is well above the number of vehicles owned in any given area.

-Gasoline stations (over 200,000 in the country; many cities have well over 1,000).

-Body repair shops, parts, supplies, dealerships, etc.

-Street and highway maintenance and lighting.

-Traffic control devices.

-Buses are, similarly, assumed not to involve any energy consumption for garaging, terminals, etc.

All of these and many other items must be included for an unbiased comparison of total systems. The CBO report considers them only for rail modes. The error is difficult to estimate, but it is obviously such that its correction would force a significant change in the conclusions of the report in favor of rail modes.

D-4. Treatment of light rail transit is entirely erroneous. From the statements that its energy consumption for stations is similar to that of heavy rail (its stations are much more similar to bus stops than to rapid transit stations), to the numbers used for its energy consumption, are simply wrong. Despite the numerous caveats about these data, the CBO proceeds to derive single numbers and make categorical statements about this mode.

D-5. The statement that auto energy efficiency will be greatly improved while energy efficiency of transit modes will not change or will even deteriorate is incorrect. By introduction of increased coasting alone rail transit can reduce energy consumption by 10-30%. Introduction of chopper control is another improvement. Actuated escalators,

energy-conscious station design (e.g., those on the Lindenwold Line) and other measures, all of which are entirely realistic and easier to implement than increased efficiency of automobiles, will improve energy efficiency of rail transit at least as much as it is likely to be improved for automobiles. Improvements in bus energy efficiency can also be expected.

E. Biases against Electric Propulsion

E-1. The CBO report also contains distinct distortions about electric propulsion. Its basic advantages are ignored, computation of consumption is incorrect, trolleybuses as a distinct mode are not mentioned.

E-2. The major advantage of electric energy is that it can be produced from any type of primary energy source: coal, hydro, nuclear, as well as oil. Since our crisis primarily concerns oil, this is a highly significant fact. In a truly serious oil crisis large segments of our pouplation would have a drastically decreased mobility; cities like Detroit, Houston and Los Angeles would face a serious economic and social crisis. But New York, Philadelphia, San Francisco and other cities with electric transit would continue to have their basic transportation services.

This fact, obviously of great importance, is not mentioned in the CBO report.

E-3. The report assumes that only 30% of primary energy is used as electricity, but considers no corresponding losses for internal combustion engines. CBO's assumption would be correct if gasoline would be poured directly from Texas or Arabian wells into gasoline tanks. In real world energy must be transported to refineries, refined into gasoline and other products, distributed, stored, etc. All these operations consume considerable energy. Another omission that biases the conclusions against rail transit and electric propulsion.

F. Quality of Sources and Data

F-1. The report has a list of references which to the layman looks impressive. However, the list includes such publications as Lave's TRB paper which has been disputed by a number of persons highly qualified in transit system planning and operations. It also includes papers with extremely uncertain, global estimates which cannot be considered highly reliable. In some cases they are obviously incorrect.

F-2. As a consequence of the preceding statement, many if not most data in the report are questionable or incorrect, particularly influenced by the consistent bias of the report. Thus, all "circuity" numbers in Table 8 are based on subjective estimates and do not correspond to real conditions: the report estimate is that trips between two points are 20-30% longer when they are made by rail modes than by auto. A look at transportation network of any city with rail transit clearly shows that this is not the case: rail transit usually provides the most direct line of travel for most passengers. Auto drivers often find that circuitous routes (utilizing freeways) are faster than the shortest ones. In many cases circuity by rail is thus lower than that by auto. This correction alone would change the results by some 20-40% in favor of rail!

Virtually all figures in Table A-6 are highly questionable.

G. Conslusions

G-1. Each one of the preceding categories shows weaknesses which are sufficient to make the results of the report invalid. Compounded, the effect of all the errors is staggering indeed. Since the biases are consistantly in one direction, it is not surprising that the conclusions of the report not only contradict the "conventional wisdon about rail transit," but they also contradict opinions of knowledgeable persons

who actually plan, design and operate transit systems. Moreover, it contradicts real world facts.

G-2. The CBO report makes numerous statements very cautiously: "possibly," "most probably," "under many conditions" are frequent terms. They correctly express the difficulty to reach reliable numbers. However, this does not prevent the authors to make sweeping categorical statements as if they had been based on an entirely different type of analysis. The statements are apparently intended for the readers who will not analyze the quality of work and numerical data.

It should be moral, if not legal duty of a high governmental agency such as the Congressional Budget Office to see that the confusion of the public with respect to the energy problem is decreased, rather than increased. Instead of employing authors with a reputation of extreme views on urban transportation, CBO should obtain and disseminate objective and responsible information and views. The Congress and the public deserve a higher quality professional work than the CBO report "Energy Saving Potential of Urban Mass Transit" presents.

8#47

URBAN TRANSPORTATION AND ENERGY: THE POTENTIAL SAVINGS OF DIFFERENT MODES

HEARING

BEFORE THE

SUBCOMMITTEE ON TRANSPORTATION

OF THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

UNITED STATES SENATE

NINETY-FIFTH CONGRESS

FIRST SESSION

ON

THE CONGRESSIONAL BUDGET OFFICE REPORT ENTITLED "URBAN TRANSPORTATION AND ENERGY: THE POTENTIAL SAVINGS OF DIFFERENT MODES"

OCTOBER 5, 1977

SERIAL NO. 95-H39

Printed for the use of the Committee on Environment and Public Works

U.S. GOVERNMENT PRINTING OFFICE
98-885 O WASHINGTON : 1977

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

JENNINGS RANDOLPH, West Virginia, *Chairman*

EDMUND S. MUSKIE, Maine
MIKE GRAVEL, Alaska
LLOYD M. BENTSEN, Texas
QUENTIN N. BURDICK, North Dakota
JOHN C. CULVER, Iowa
GARY HART, Colorado
WENDELL R. ANDERSON, Minnesota
DANIEL PATRICK MOYNIHAN, New York

ROBERT T. STAFFORD, Vermont
HOWARD H. BAKER, JR., Tennessee
JAMES A. McCLURE, Idaho
PETE V. DOMENICI, New Mexico
JOHN H. CHAFEE, Rhode Island
MALCOLM WALLOP, Wyoming

JOHN W. YAGO, JR., *Staff Director*
BAILEY GUARD, *Minority Staff Director*
LEON G. BILLINGS and HAROLD H. BRAYMAN (Minority),
Senior Professional Staff Members
PHILIP T. CUMMINGS, RICHARD M. HARRIS, RICHARD E. HEROD (Minority), and
KATHERINE Y. CUDLIPP (Minority), *Associate Counsels*

Professional and research staff: KARL R. BRAITHWAITE, PAUL CHIMES, E. KEVIN CORNELL, GEORGE F. FENTON, JR., RANDOLPH G. FLOOD, KATHALEEN R. E. FORCUM, JOHN D. FRESHMAN, ANN GARRABRANT, RICHARD T. GREER, WESLEY F. HAYDEN, VERONICA A. HOLLAND, RONALD L. KATZ, KATHLEEN A. KORPON, JUDY F. PARENTE, JOHN B. PURINTON, JR., JAMES D. RANGE (*Assistant Counsel, Minority*), JACQUELINE E. SCHAFER, CHARLENE A. STURBITTS, E. STEVENS SWAIN, JR., ROBERT VAN HEUVELEN, SALLY W. WALKER, and HAVEN WHITESIDE

SUBCOMMITTEE ON TRANSPORTATION

LLOYD M. BENTSEN, Texas, *Chairman*

QUENTIN N. BURDICK, North Dakota
JOHN C. CULVER, Iowa
DANIEL PATRICK MOYNIHAN, New York

JOHN H. CHAFEE, Rhode Island
ROBERT T. STAFFORD, Vermont
PETE V. DOMENICI, New Mexico

CONTENTS

OPENING STATEMENTS

LIST OF WITNESSES

ADDITIONAL MATERIAL